contaminants produced. A prototype incinerator was delivered to Johnson Space Center as part of an extended closed 90-day manned chamber test. All product gases met Spacecraft Maximum Allowable Contaminant standards, and the CO_2 product gas was used to supply CO_2 to a wheat crop included in the 90-day closed test. The U.S. Navy has expressed interest in SCWO technology because of its potential for reducing hazardous liquids to CO_2 and H_2O while ships are at sea.

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U.S. Army Application for NASA Technology

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The purpose of this project was to use NASA technology to assist the U.S. Army in the assessment of motion sickness incidences in the command and control vehicle (C2V). The NASA technology utilized is U.S. Patent No. 5,639,436, Autogenic-Feedback Training Exercise system and method. During this study we determined the frequency and severity of motion sickness in personnel during a field exercise in the C2V. This vehicle contains four workstations where military personnel are expected to perform command decisions in the field during combat conditions. Eight active duty military men (U.S. Army) at the Yuma Proving Grounds in Arizona participated in this study. On the first day, all subjects were given baseline performance tests while their physiological responses were monitored. On the second day of their participation, subjects rode in the C2V while their physiological responses and performance measures were recorded. Self-reports of motion sickness were also recorded, with only one subject experiencing two incidences of emesis. Seven out of the eight subjects reported other motion sickness symptoms; most predominant was the report of drowsiness, which occurred a total of 19 times. The table summarizes symptom reports, hours of sleep obtained on the previous night, seat position in the C2V, and previous experience in this or other tracked vehicles.

Changes in physiological responses were observed relative to motion sickness symptoms reported and the different environmental conditions (i.e., level, hills, and gravel) during the field exercise. The subject who reported the most symptoms (subject 3), and the one who reported no symptoms at all (subject 6), both rode in the C2V on the same day. The first figure shows the physiological data of both individuals which are plotted as 1-minute averages across time. C2V courses are represented as

Table 1. Motion sickness symptoms during the command and control vehicle (C2V) field exercise

I.D.	VMT	TMP	DIZ	HAC	DRZ	SWT	PAL	SAL	NSA	ED	EA	Previous experience	Seat position	Hours sleep
# 1					3							Yes	4	6.5
# 2					2							No	1	4.5
# 3	2	4	3		4	3	1	1	3			No	1	4.0
# 4					1							Yes	4	6.5
# 5			3	1	1				1			No	1	5.0
# 6												Yes	4	4.5
# 7		1		1	4	1		1	1	2	2	No	1	7.0
# 8		2	2		4	1						Yes	4	6.0
Total	2	7	8	2	19	5	1	2	5	2	2			

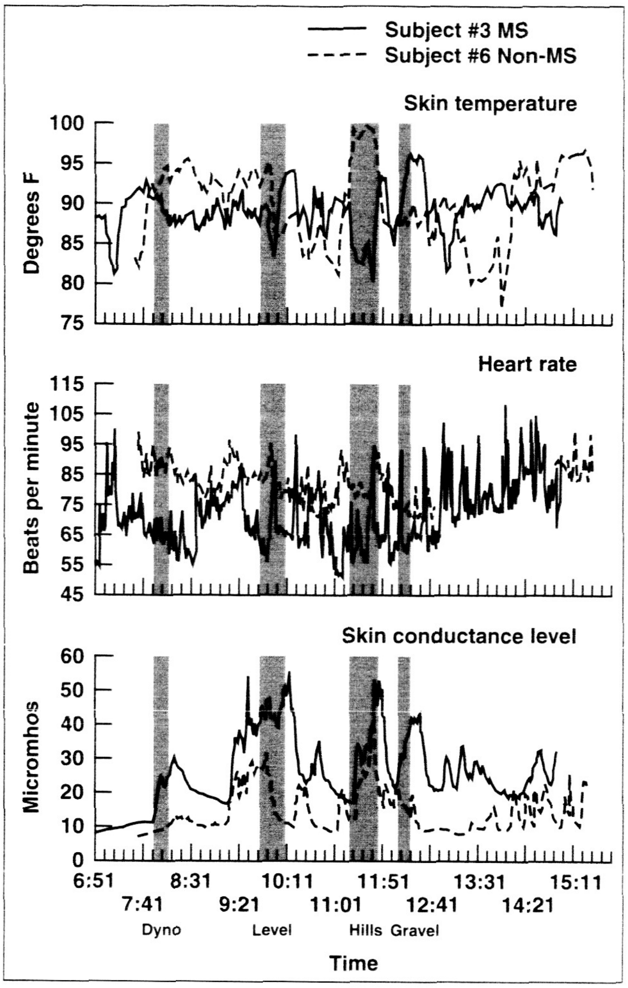

Fig. 1. Comparison of motion sickness and non–motion sickness subjects during the C2V exercise.

bars. The bottom graph shows the skin conductance level of both subjects. This response reflects minute changes in the electrolytic properties of the skin (i.e., sweat), which are generally too small to be perceived as changes in "wetness," and is a very sensitive index of physiological and emotional arousal. Note that both subjects began the day with relatively low levels in skin conductance, and both responded to changes in terrain. The response increases (i.e., arousal) that began several minutes before actually reaching the level course probably reflect the point where they began operating video game terminals and/or the response to movement of the vehicle as they drove to the next course. Subject 3, however, made much larger increases in this response, which were of longer duration than those of subject 6, and which never returned to the prestimulus levels recorded at the start of the day (i.e., less than 10 micromhos).

Performance data show an overall decrement during the C2V exercise. These preliminary results suggest that malaise and severe drowsiness can potentially impact the operational efficiency of the C2V crew. However, a number of variables (e.g., individual's sleep quantity prior to the mission, prior experience in the C2V, etc.) were not controlled for in this study and may have influenced the results. Most notably was the fact that subjects with previous experience in the C2V all occupied seat 4, which was anecdotally reported to be the least provocative position. Subjects were assigned on an "as available" basis, and the investigators had no prior knowledge of the subjects' experience in tracked vehicles. Composite performance latency shows the expected exponential learning pattern over training trials 1 through 8 (see second figure). On the C2V day, task batteries were administered only when the vehicle was not moving. The vehicle doors were opened and Yuma Proving Ground personnel provided lap-top computers for the subjects' use.

It was concluded that a second study is required to further evaluate the impact of seat position, orientation, and C2V experience on motion sickness susceptibility. Further, it was concluded that it is unlikely that pharmacological intervention or crew preselection/screening will mitigate the problem.

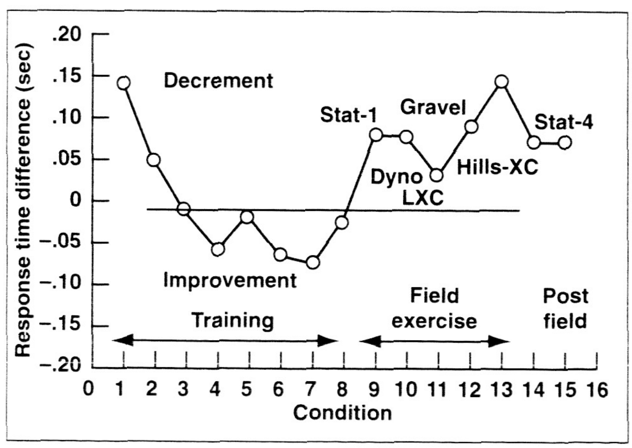

Fig. 2. Mean response latency (5 tests): residuals after subtraction of learning curve.

Investigation of behavioral methods for improving crew alertness, motivation, and performance and reducing malaise is recommended. The value of utilizing three separate converging indicators—physiological measures, performance measures, and standardized symptom reports—has been demonstrated as an effective means of assessing environmental impacts on the safety and well-being of human passengers or crew on land, sea, air, and space vehicles.

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Virtual Environment Surgery and the Virtual Hospital

Muriel D. Ross, Jeffrey D. Smith

The Biocomputation Center is dedicated to computer-based three-dimensional (3-D) visualization, mathematically based modeling, and 3-D simulation. The emphasis is on teams of broadly based, interdisciplinary investigators, and on a union between computational, theoretical, and experimental research. Virtual environment surgery (VES) technologies of the Biocomputation Center have found several new applications in FY97, including breast cancer imaging research and 3-D ultrasound and computed tomography (CT) visualization tools. In addition, the first steps have been taken toward creating a virtual hospital, linking several clinical institutions using the VES technology and the Next Generation Internet/NASA Research and Education Network (NGI/NREN).

The Biocomputation Center maintains state-of-the-art virtual environment technologies for 3-D viewing and interaction. The Fakespace Immersive Workbench (Fakespace, Mountain View, California) acts as a viewing interface into a virtual environment. The workbench is large and permits several individuals to see the visualization projected above the tabletop in 3-D. Special Crystal Eyes glasses (Stereographics, San Ramon, California) are required for 3-D viewing. Users have full control of viewing angle, position, and perspective. The Fakespace Pinch Glove, in conjunction with a Polhemus radio-tracking device (Framingham, Massachusetts), allows the user to interact with the virtual environment by grabbing and moving objects. The Immersive Workbench, associated hardware, and the VES software are driven by a Silicon Graphics Onyx RE2 workstation.

The Ames Biocomputation Center has a long history of success in processing, manipulation, and visualization of large 3-D biological datasets. In FY97, with the permission of the Stanford Radiology Group, the VES technologies were applied to magnetic resonance imagery (MRI) of breast cancer for visualization, modeling, and virtual environment surgery applications as shown in part (a) of the first figure. Women's health issues are of increasing importance to NASA now that one half of future astronauts will be women. This new research effort improves upon previous methods for breast cancer visualization, and will help to model the motion of the tumor within the breast as a woman's body shifts during diagnosis and surgery. In addition, emerging methodologies resulting from this breast cancer imaging application will apply directly to NASA's interests in other MRI, Ultrasound, and Space applications.

The Biocomputation Center has used its specialized VES software and computing facilities to process 3-D datasets of the heart. A post-operational CT scan of the heart showing a graft was visualized using the same software as shown in part (b) of the figure. In the future, this segmentation and visualization technology will be applied to 3-D ultrasound datasets from the Cleveland Clinic Foundation, Department of Cardiovascular Imaging.

Today, there is a need for a collaborative virtual environment to perform interactive surgical planning, practice, and education activities. The Biocomputation Center has begun the process of creating a virtual hospital to connect Stanford University